Appendix 5.2 Calculations for Dissolved Metals

Appendix 5.2 Calculations for Dissolved Metals

Hydrocarbons, PAHs, barium and molybdenum were not included in the calculations as they are highly insoluble and are assumed to remain in the soil when in contact with surface runoff or seawater.

With reference to S. Sauvé et. al, 2000[1], the below formula has been adopted to calculate the amount of heavy metals migration from soil to water using the partitioning coefficients and total heavy metal contents. The partitioning coefficients and heavy metals adopted have been summarised in **Table 1**. Heavy metals such as cobalt and molybdenum were not selected as they are highly insoluble in water and therefore considered to have minimal impact.

$$[Metal_{dis}] = \frac{[Metal\ total]}{Kd}$$

$[Metal_{dis}]$ = Heavy metal dissolved in water
[*Metal total*] = Heavy metal concentraction in soil
Kd = Partioning Coefficients

Table 1: Partitioning Coefficents (S. Sauvé et. al, 2000)

Metals		Partitioning Coefficients (Kd)* (L/kg)
Arsenic	As	13,119
Cadmium	Cd	2,869
Chromium (III)	Cr(III)*	14,920
Chromium (IV)	Cr(IV)*	14,920
Copper	Cu	4,799
Nickel	Ni	16,761
Lead	Pb	171,214
Zinc	Zn	11,615
Mercury	Hg	8,946

*Note: Partitioning coefficient for Chromium was adopted for both Cr(III) and Cr(IV).

Grids 1 and 15 were selected for calculating the dissolved metals and mixing zones, due to the higher heavy metal contents in the grids and the promixity of the grids to the marine environment. The minimum, maximum and average heavy metals were identified from the numerous bored hole results within the concerned grids, and these results were used for calculating the dissolved metals range. A summary of the calculated dissolved metals for Grids 1 and 15 are presented in **Table 2**.

Table 2: Summary of Calculated Dissolved Metals in Grids 1 and 15

Chemical		Criteria (µg/L)	Content (µg/L) Grid 1			Grid 15		
			Min	Max	Avg	Min	Max	Avg
Arsenic	As	69.0	0.1	4.0	0.6	0.1	1.9	0.5
Cadmium	Cd	40.0	0.0	**48.8**	4.1	0.0	0.9	0.1
Chromium (III)	Cr(III)*	1,000	0.4	9.1	3.7	0.0	1.3	0.5
Chromium (IV)	Cr(IV)	1,100	0.2	9.1	1.8	0.0	2.5	0.8

[1] S. Sauve, W. Hendershot and H.E. Allen, *Solid-Solution Partitioning of Metals in Contaminated Soils: Dependence on pH, Total Metal Burden, and Organic Matter*, Environmental Science & Technology, Vol. 34, No. 7 (2000)

Chemical		Criteria (µg/L)	Content (µg/L)					
			Grid 1			Grid 15		
			Min	Max	Avg	Min	Max	Avg
Copper	Cu	1	0.3	**149.4**	**17.0**	0.9	**86.5**	**14.9**
Nickel	Ni	74	0.1	2.3	0.5	0.0	2.9	0.7
Lead	Pb	210	0.1	60.2	5.5	0.1	6.6	0.9
Zinc	Zn	90	0.5	**2626.8**	**201.4**	2.1	74.9	14.6
Mercury	Hg	1.8	0.0	0.1	0.0	0.0	0.1	0.1

Note: Grey shaded items exceed the relevant criteria.
*Council Directive on the quality required of shellfish waters (Shellfish Waters Directive), repealed by the codified Directive on the quality required of shellfish waters, http://evidence.environment-agency.gov.uk/ChemicalStandards/Driver.aspx?did=13, 16 June 2014.

The calculated dissolved metal contents were further used to calculate the discharge rate using the following formula. For worst case assumptions, the runoff percentage of wet (93 %) season calculated in the HATS Stage 2A EIA report[2], the whole project area (32,000m^2) and the maximum dissolved metal content identified in **Table 2** that exceeded the relevant criteria have been adopted for use to calculate the daily runoff volume and discharge rate. A summary of the calculated discharge rates is presented in **Table 3**.

The updated thirty-year long term average rainfall data (1981 to 2010) was used to determine the daily runoff value as shown below:

Daily runoff value (m/day) = thirty-year long term average daily rainfall data x runoff percentage

Thus, the runoff value was calculated as 0.01150 m/day.

Daily runoff volume (m^3/d) = daily runoff value (m/d) × project area (m^2)
= 0.01150 × 32000
= 368 m^3/d

Discharge rate (q) (g/d) = {[dissolved metals] (µg/L) × daily runoff volume (m^3/d)} ÷ 1000

Table 3: Summary of Calculated Dissolved Metals in Grids 1 and 15 without Treatment

Chemical		Discharge rate (g/d)	
		Grid 1	Grid 15
Cadmium	Cd	17.96	N/A
Copper	Cu	54.98	31.82
Zinc	Zn	966.65	N/A

A simple model is then adopted to calculate the dissolved metal concentrations along the centreline of a plume by solving the advection-diffusion equation for a continuous line source[3]. This model is considered appropriate for the calculation of dissolved metals because the equation is based on a continuous line source of sediment, which is a reasonable approximation of the heavy metals release, assuming a similar property between suspended sediments and heavy metals.

The equation used in this model is appropriate for areas where the tidal current is unidirectional for each phase of the tidal cycle (i.e. the ebb and flood phases), which is the case at the Project area where the tidal current is also uni-directional for each phase of the tidal cycle.

[2] Drainage Service Department, *EIA Report (ref. EIA-148/2008) for Harbour Area Treatment Scheme (HATS) Stage 2A*
[3] R E Wilson, *A Model for the Estimation of the Concentrations and Spatial Extent of Suspended Sediment Plumes*. Estuarine and Marine Coastal Science (1979), Vol 9, pp 65-78

The near field concentration formula is as follows:

$$C(x) = \frac{q}{(D \times x \times \omega \times \sqrt{\pi})}$$

where:
C(x) = concentration at distance x from the source (mg/L);
q = Heavy metal release rate (kg/s);
D = water depth (5 m);
x = distance from source (m);
w = diffusion velocity (0.01 m/s).

The diffusion velocity represents reductions in the centre-line concentrations due to lateral spreading, the value of 0.01m/s was recommended by Wilson, 1979 and adopted for the EIA reports of OISS and IWMF. The calculated heavy metal concentrations at various distances are presented in **Table 4**. The distance of the mixing zone can be referred to **Figure 1** of this appendix.

Table 4: Calculated Heavy Metal concentrations from Grids 1 and 15 without Treatment

	Grid 1			Grid 15
Distance (m)	**Cadmium (Cd)**	**Copper (Cu)**	**Zinc (Zn)**	**Copper (Cu)**
Criteria (µg/L)	**1**	**4.8**	**90**	**4.8**
1	**2.35E+00**	**7.18E+00**	**1.26E+02**	4.16E+00
2	**1.17E+00**	3.59E+00	6.31E+01	2.08E+00
5	4.69E-01	1.44E+00	2.52E+01	8.31E-01
10	2.35E-01	7.18E-01	1.26E+01	4.16E-01
20	1.17E-01	3.59E-01	6.31E+00	2.08E-01

Note: Grey shaded items exceed the relevant criteria.

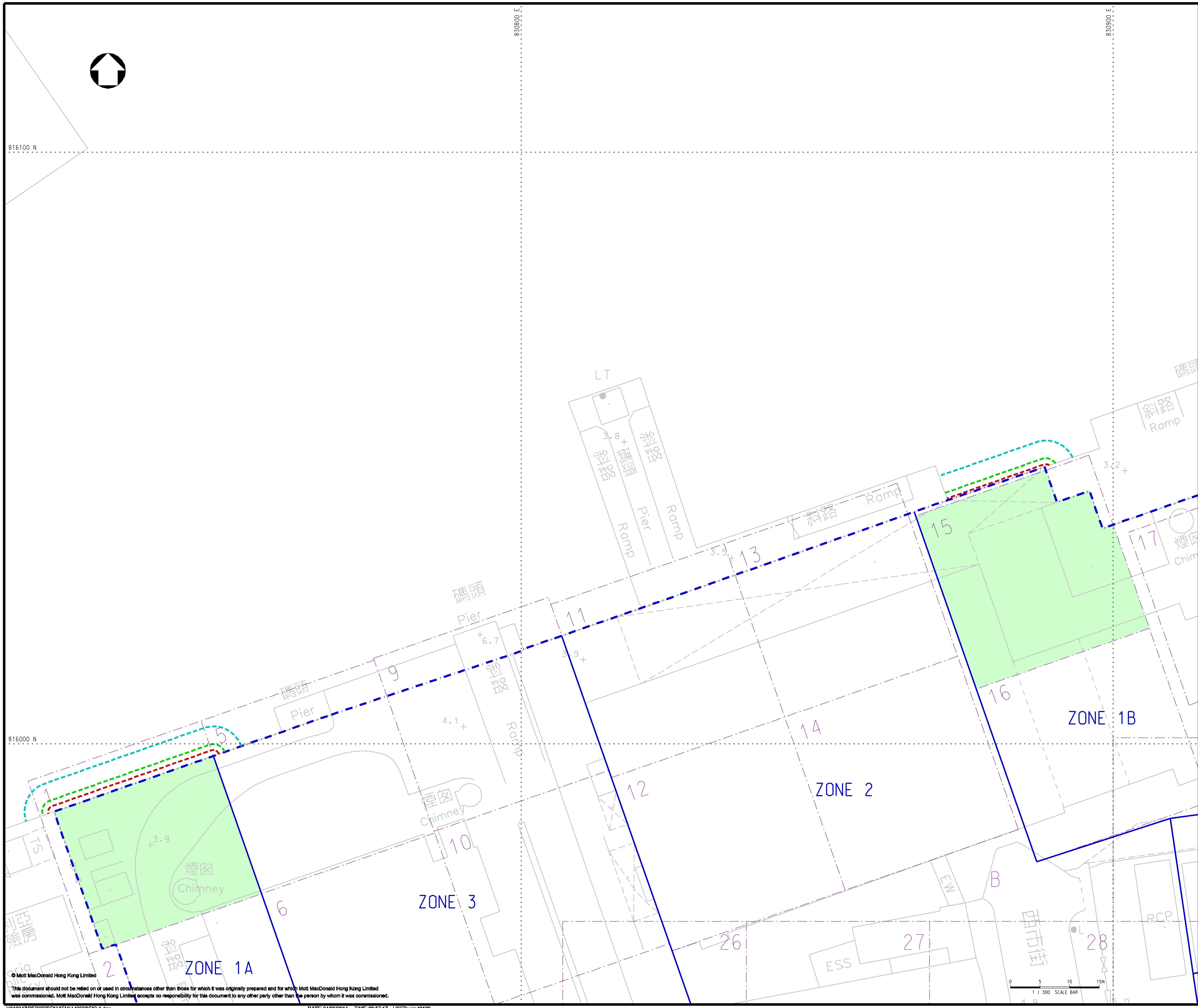
The on site wastewater treatment facilities will be fitted with an activated carbon filter for treatment before discharge. According to González et. al, 2014[4], the removal efficiency for dissolved metals using activated carbon varies with concentration and time, but the figures are all above 80%. As such, an 80% reduction has been adopted to represent the treatment efficiency of the wastewater treatment facilities.

Table 5: Calculated Heavy Metal concentrations from Grids 1 and 15 after treatment

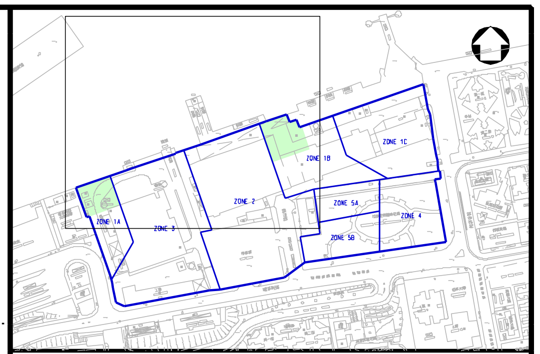
	Grid 1			Grid 15
Distance (m)	**Cadmium (Cd)**	**Copper (Cu)**	**Zinc (Zn)**	**Copper (Cu)**
Criteria (µg/L)	**1**	**4.8**	**90**	**4.8**
1	4.69E-01	1.44E+00	2.52E+01	8.31E-01
2	2.35E-01	7.18E-01	1.26E+01	4.16E-01
5	9.38E-02	2.87E-01	5.05E+00	1.66E-01
10	4.69E-02	1.44E-01	2.52E+00	8.31E-02
20	2.35E-02	7.18E-02	1.26E+00	4.16E-02

Note: Grey shaded items exceed the relevant criteria.

[4] González, P.G., Pliego-Cuervo, Y.B., *Adsorption of Cd(II), Hg(II) and Zn(II) from aqueous solution using mesoporous activated carbon produced from Bambusa vulgaris striata*. Chem. Eng. Res. Des. (2014), http://dx.doi.org/10.1016/j.cherd.2014.02.013



J:\316047\REPORT\ENV\EIA\140623\FIG 1.dgn DATE: 24/06/2014 TIME: 09:57:17 USER: yim42169



KEY PLAN
SCALE 1:3000

LEGEND:

- PROJECT SITE BOUNDARY
- PREVIOUS GRID
- 5m ASSESSMENT AREA
- 2m ASSESSMENT AREA
- 1m ASSESSMENT AREA
- ASSESSMENT GRID

Reference drawings

Rev	Date	Drawn	Description	Ch'k'd	App'd
P1	JUN 14	MING	FIRST ISSUE	FK	AFK

Mott MacDonald
20/F Two Landmark East
100 How Ming Street
Kwun Tong, Kowloon
Hong Kong
T +852 2828 5757
F +852 2827 1823
W www.mottmac.com.hk

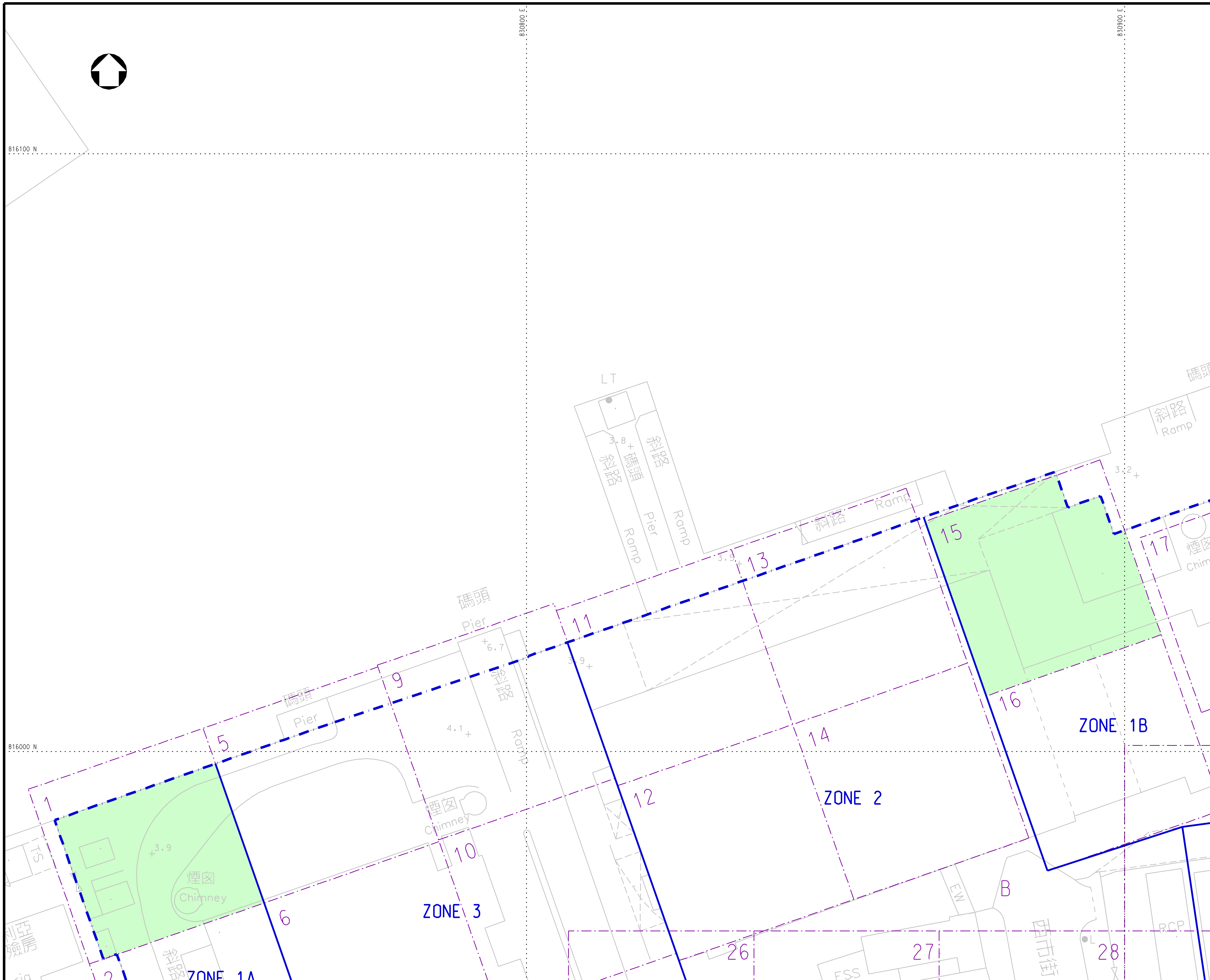
Client
CEDD
CIVIL ENGINEERING AND DEVELOPMENT DEPARTMENT

Project
ALTERNATIVE GROUND DECONTAMINATION WORKS AT THE PROPOSED KENNEDY TOWN COMPREHENSIVE DEVELOPMENT AREA SITE

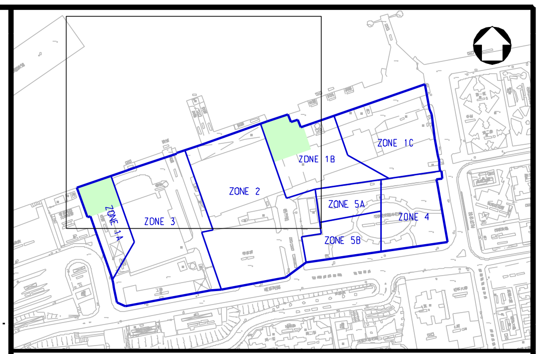
Title
POTENTIAL MIXING ZONE DISTANCE

Designed	FK	Eng check	TK
Drawn	MING	Coordination	FW
Dwg check	FK	Approved	AFK
Scale at A1: 1:300	Status: PRE	Rev: P1	

Drawing Number
FIGURE 1



J:\316047\REPORT\ENV\EIA\140704\FIG 2.dgn DATE: 04/07/2014 TIME: 09:38:08 USER: yim42169



KEY PLAN
SCALE 1:3000

LEGEND:

- PROJECT SITE BOUNDARY
- PREVIOUS GRID
- ASSESSMENT GRID

Reference drawings

Rev	Date	Drawn	Description	Ch'k'd	App'd
P1	JUL 14	MING	FIRST ISSUE	FK	AFK

Mott MacDonald

20/F Two Landmark East
100 How Ming Street
Kwun Tong, Kowloon
Hong Kong
T +852 2828 5757
F +852 2827 1823
W www.mottmac.com.hk

Client

CIVIL ENGINEERING AND DEVELOPMENT DEPARTMENT

Project

ALTERNATIVE GROUND DECONTAMINATION WORKS AT THE PROPOSED KENNEDY TOWN COMPREHENSIVE DEVELOPMENT AREA SITE

Title

POTENTIAL MIXING ZONE DISTANCE AFTER TREATMENT

Designed	FK	Eng check	TK
Drawn	MING	Coordination	FW
Dwg check	FK	Approved	AFK

Scale at A1	Status	Rev
1:300	PRE	P1

Drawing Number

FIGURE 2